U.S. Department of the Interior
Bureau of Land Management

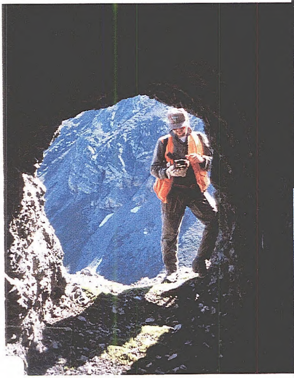
Alaska State Office
222 W. Seventh Avenue, #13
Anchorage, Alaska 99513

BLM-Alaska Technical Report 34
BLM/AK/ST-00/019+3091+932
May 2000

Mineral Assessment of Ahtna, Inc. Selections in the Wrangell-St. Elias National Park and Preserve, Alaska

Executive Summary

Mark P. Meyer, Darrel A. VandeWeg, and Andrew D. Shepherd



Mission Statement

The Bureau of Land Management sustains the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

Authors

Mark P. Meyer is a geologist with the Bureau of Land Management's Alaska State Office, Division of Lands, Minerals, and Resources, Anchorage Mineral Resources Team. Darrel A. VandeWeg was a geological field assistant for the Anchorage Mineral Resources Team during 1998 through 1999. Andrew D. Shepherd was a geological field assistant during 1997.

Cover photos

Left - Darrel VandeWeg collecting GPS location data at the Cave Prospect Adit No. 2 on Copper Creek, a southern tributary of the Kotsina River. Photo by Mark P. Meyer. Upper right - Mark P. Meyer taking field notes at the Warner prospect adit on Rock Creek, a southern tributary of the Kotsina River. Photo by Darrel A. VandeWeg. Lower Right - Andrew Shepherd collecting GPS location data at the Clear Creek Mine lower opencut on Clear Creek, a northern tributary of the Kuskulana River. Photo by Mark P. Meyer.

Technical Reports

Technical Reports issued by the Bureau of Land Management - Alaska present the results of research, studies, investigations, literature searches, testing, or similar endeavors on a variety of scientific and technical subjects. The results presented are final, or are a summation and analysis of data at an intermediate point of a long-term research project, and have received objective review by peers in the author's field.

The reports are available while supplies last from BLM External Affairs, 222 West 7th. Avenue, #13, Anchorage, Alaska 99513 and from the Juneau Minerals Information Center, 100 Savikko Road, Mayflower Island, Douglas, AK 99824, (907) 364-1553. Copies are also available for inspection at the Alaska Resources Library and Information Services (Anchorage), the USDI Natural Resources Library in Washington, D.C., various libraries of the University of Alaska, the BLM National Business Center Library (Denver), and other selected locations.

A complete bibliography of all BLM-Alaska scientific reports can be found on the Internet at: http://www.ak.blm.gov/affairs/sci_rpts.html. Related publications are also listed at http://juneau.ak.blm.gov.

Mineral Assessment of Ahtna, Inc. Selections in the Wrangell-St. Elias National Park and Preserve, Alaska

Executive Summary

by

Mark P. Meyer
Darrel A. VandeWeg
Andrew D. Shepherd

BLM-Alaska Technical Report 34
May 2000

U.S. Department of the Interior
Bureau of Land Management

TABLE OF CONTENTS

	Page
Introduction	1
General geology	5
Mineral resources	8
Copper deposits	8
Stringer lodes	8
Contact deposits	10
Gold deposits	10
Molybdenite and corundum deposits	10
Kennecott type deposits	11
Nabesna type deposits	12
Mineral deposit models	13
Site investigations	14
Northern Wrangell Mountains	14
Southern Wrangell Mountains	19
Kluvesna River prospects	19
Kotsina River prospects	23
Kuskulana River prospects	27
Elliott Creek prospects	29
Canyon Creek prospects	30
Other prospects	32
Economic analysis	33
Summary	34
Northern Wrangell Mountains	34
Southern Wrangell Mountains	34
References	38

TABLES

1. Properties located within Ahtna, Inc. selections, Wrangell-St. Elias National Park and Preserve 3
2. Properties located outside Ahtna, Inc. selections, Wrangell-St. Elias National Park and Preserve 4
3. Mineral occurrence types and descriptions 9
4. Mineral deposit models and descriptions 13
5. Highest analytical results of selected properties within Ahtna, Inc. selections in the Wrangell-St. Elias National Park and Preserve 18
6. Highest analytical results of selected properties outside Ahtna, Inc. selections in the Wrangell-St. Elias National Park and Preserve 19

TABLE OF CONTENTS--Continued

FIGURES

Page

1. Location map of the Wrangell-St. Elias National Park and Preserve showing Ahtna, Inc. lands 2
2. Geologic map of the Wrangell-St. Elias National Park and Preserve 7
3. Property location map of the northern study area Wrangell-St. Elias National Park and Preserve ... 15
4. Inset A (Fig. 3), property location map of the northern study area 16
5. Inset B (Fig. 3), property location map of the northern study area 17
6. Property location map of the southern study area Wrangell-St. Elias National Park and Preserve ... 20
7. Inset C (Fig. 4), property location map of the southern study area 22
8. Inset D (Fig. 4), property location map of the southern study area 24
9. Inset E (Fig. 4), property location map of the southern study area 28
10. Inset F (Fig. 4), property location map of the southern study area 31
11. Mineral terranes map showing selected properties in the northern study area 35
12. Mineral terranes map showing selected properties in the southern study area 36

ILLUSTRATIONS

1. Mullen Mine cairn, looking northeast toward the Kluvesna River valley 1
2. View looking northeast toward Mount Drum and Mt. Wrangell from the Copper River 4
3. The Copper King Mine on upper Elliott Creek showing the distinct cliffs of the Chitistone Limestones, looking east 5
4. Kennecott Mill buildings, looking north 11
5. The Nabesna Mine mill and mine workings, looking northwest at White Mountain 12
6. BLM employee sampling the upper vein at the Rambler Mine 14
7. BLM geologist inspecting bedrock in the vicinity of the Sunrise prospect 21
8. Mullen Mine No. 1 adit tailings, looking northwest 23
9. Bluebird prospect opencut showing the copper mineralization 25
10. BLM geologist exiting the Warner prospect adit 26
11. The Surprise/Sunshine opencut no. 1 showing the reddish tinted quartz vein 27
12. View looking north at the Silver Star Mine 27
13. Clear Creek mine Tunnel No. 1, looking southeast 29
14. The Copper King Mine - Mineral King Lode adit 30
15. Divide Creek Opencut No. 3 copper mineralization 30
16. The Peninsula showing Rock Creek draining into the Kotsina River 32
17. Looking northeast into the headwaters of the Kluvesna River, a tributary of the Kotsina River 37

Unit of Measure Abbreviations

in	inches
ft	feet
mm	millimeter
ppb	parts per billion
ppm	parts per million
%	percent
sq ft	square foot
st	short tons
stpd	short tons per day

MINERAL ASSESSMENT OF AHTNA, INC. SELECTIONS IN THE WRANGELL-ST. ELIAS NATIONAL PARK AND PRESERVE, ALASKA

EXECUTIVE SUMMARY

INTRODUCTION

This Executive Summary is part of a series on the mineral assessment of Ahtna, Inc. Regional Native Corporation (Ahtna, Inc.) selections within the Wrangell-St. Elias National Park and Preserve, Alaska. This publication summarizes the results of the Bureau of Land Management's (BLM) 1996-1998 mineral assessment and also includes a summary of the economic analysis (Coldwell, 2000). The Final Report (Meyer and others, 2000) consists of a detailed description of the multi-year mineral assessment of the mines, prospects, and occurrences identified during this study and includes detailed property summary sheets for each mine, prospect, and occurrence.

In 1996, the National Park Service (NPS), BLM, and Ahtna, Inc. signed a memorandum of understanding (MOU) requesting the BLM provide comprehensive minerals information and conduct a mineral assessment on federal lands selected by Ahtna, Inc. in the west-central to northern part of the Wrangell-St. Elias National Park and Preserve (Figure 1). The BLM has authority to conduct Mineral Assessment activities under section 1010 of the Alaska National Interest Lands Conservation Act (ANILCA).

This project was undertaken to identify the number, type, distribution, and economic potential of mineral deposits located in and within close proximity to Ahtna, Inc. selected lands. A literature search and two seasons of field work identified 82 mineral occurrences within three miles of the selections. Forty-six of those are located within Ahtna, Inc. selections, with 14 located in the northern area and 32 located in the southern area (Table 1). Thirty-six of the properties are located outside of the Ahtna, Inc. selections, with 8 located in the northern area and 28 located in the southern area (Table 2). See the property summaries in the Final Report - Appendix B for a detailed description of each prospect.

Photo 1. - Mullen Mine cairn, looking northeast toward the Kluvesna River valley. Photo by Darrel A. VandeWeg.

Investigations in the northern Wrangell Mountains disclosed no significant hard rock mineral occurrences other than the Nabesna, Rambler, and Royal Development Co. mines inside the selections.

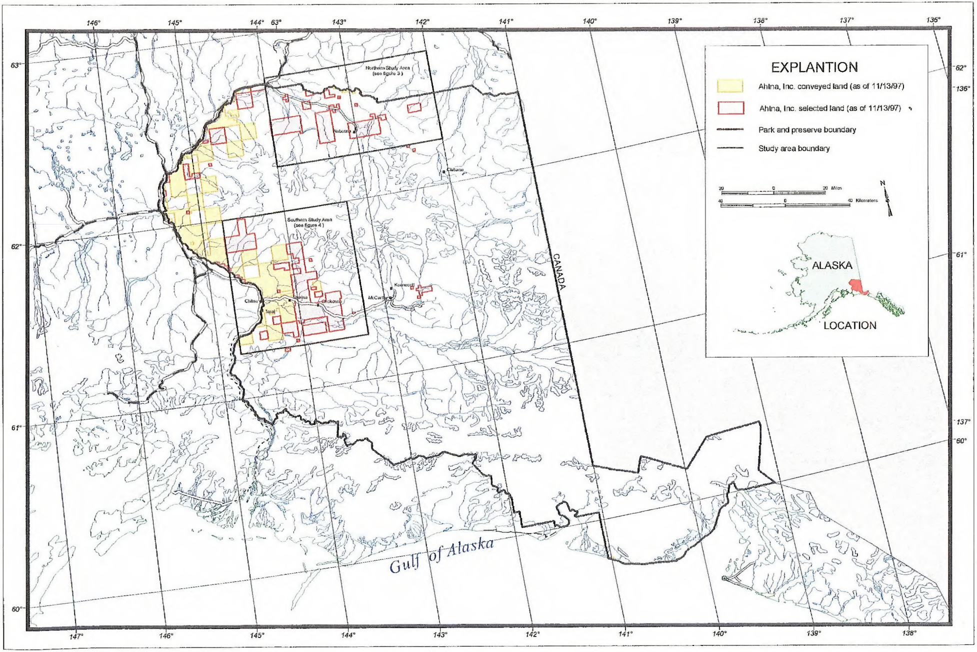


Figure 1. - Location map of the Wrangell-St. Elias National Park and Preserve showing Ahtna, Inc. lands.

The Nabesna and Royal Development Co. mines are patented and thus privately held. The NPS has proposed a validity determination on the Rambler Mine and at this time the property is unavailable for selection. The Caribou Creek Mine and Trail Creek Occurrence contain placer gold values that warrant further delineation of the mineral deposits.

Investigations in the southern Wrangell Mountains identified 15 properties with significant mineral values inside Ahtna, Inc. selections. Properties include the Clear Creek, Copper King, Mullen, and Silver Star mines and the Ammann, Barrett Young and Nafsted, Carmalita, Fall Creek Upper, Hidden Treasure, Homestake, Larson, Lime Creek, Newhome, Sunrise, and Sunset prospects. Three patented properties occur within the selections; the Clear Creek, Copper King, and Mullen mines.

Eleven historically producing mines occur in the study area. They are the Caribou Creek, Nabesna, Royal Development Co., and Rambler mines in the northern Wrangell Mountains and the southern Wrangell Mountains include the Berg Creek, Clear Creek, Copper King, Hubbard-Elliott, Mullen, Nugget Creek, and Silver Star mines.

TABLE 1 - Properties located within Ahtna, Inc. selections, Wrangell-St. Elias National Park and Preserve, Alaska.

Northern Wrangell Mountains		
Antler Creek North	Caribou Creek Mine	Royal Development Co.
Bee Jay	Caribou Creek Prospect	Trail Creek
Boyden	Nabesna Mine	Unnamed Occurrence 1
Camp Creek 1	Platinum Creek	Unnamed Occurrence 2
Camp Creek 2	Rambler Mine	
Southern Wrangell Mountains		
Ammann Prospect	Fall Creek Saddle Occurrence	Newhome
Barrett Young and Nafsted	Fall Creek Upper Prospect	O'Hara
Blackburn	Franklin	Porcupine Creek Head
Carmalita	Good Enough	Porcupine Creek Mouth
Chichokna	Hidden Treasure	Silver Star Mine
Chokosna River	Homestake	Squaw Creek
Clear Creek Mine	Kinney-Golden	Strelna Creek
Copper King Mine	Larson	Sunrise
Crawford	Lime Creek	Sunset
Dottie	Mineral Creek	Surprise Creek
Escape	Mullen Mine	

TABLE 2 - Properties located outside Ahtna, Inc. selections, Wrangell-St. Elias National Park and Preserve, Alaska.

Northern Wrangell Mountains		
Antler Creek South	Rock Creek Moly	Trail Creek Shear
Corundum	Trail Creek Cirque	Vicki
Fennimore & Rasmussen	Trail Creek Cirque North	
Southern Wrangell Mountains		
Alaska Copper Mines	Forget-Me-Not	Peacock Claim
Amy Creek	Hubbard-Elliott Mine	Roaring Creek
Berg Creek Mine	Kotsina River	Roaring Creek Southeast
Bluebird	London and Cape	Roaring Creek Southwest
Bunker Hill	Lost Cabin	Skyscraper
Calcite	Minneapolis	Skyscraper Peak West
Cave Prospect	Montana Boy	Surprise/Sunshine
Copper Queen	Mountain Sheep	War Eagle
Divide Creek	Nugget Creek Mine	Warner
Falls Creek		

Photo 2. - View looking northeast toward Mount Drum and Mt. Wrangell from the Copper River. Mount Drum is to the left. Photo by Mark P. Meyer.

GENERAL GEOLOGY

Two diverse physiographic terrains characterize the study area: the northern Wrangell Mountains and the southern Wrangell Mountains. Low-lying, broad glacial valleys and steep mountainous terrain characterize the northern Wrangell Mountains. The Denali Fault, an active northwest trending strike-slip fault, separates the northern area into a northern and a southern half. All mineral localities identified in this study occur south of the Denali Fault.

The southern Wrangell Mountains are characterized by the low-lying, broad Chitina River Valley, which separates the steep mountainous terrain of the Wrangell Mountains from that of the Chugach Mountains. The Border Ranges Fault, cutting the Chugach Mountains, forms the southern boundary of the study area. All mineral localities identified in the southern area occur north of the Border Ranges Fault.

Figure 2 shows the geology of the Wrangell-St. Elias National Park and Preserve based on Helen Beikman's (1980) USGS Geologic Map of Alaska. The oldest rocks belong to the Paleozoic volcanic Skolai Arc, which apparently developed on ancient oceanic crust. The arc is overlain by thick sequences of Paleozoic and Mesozoic sedimentary and volcanic rocks with both the arc and younger rocks intruded by Mesozoic and Cenozoic plutons and dikes. Cenozoic Wrangell Lava unconformably overlies all older rocks.

Early Mesozoic greenstones and limestones locally host the known mineral deposits throughout much of the study area. Mineralization is limited to a few specific rock types. The Triassic Nikolai Greenstone and the overlying Chitistone Limestone host the majority of the copper deposits. These two rock types host the large basaltic copper deposit at Kennecott, as well as other smaller basaltic copper deposits in the southern Wrangell Mountains. One driving force behind the mineralization is the Jurassic through Tertiary plutons, sills, and dikes that intrude the greenstones and limestones. Elsewhere, at the Nabesna Mine, an Upper Triassic limestone was intruded by the Cretaceous monzodiorite Nabesna pluton creating replacement massive oxide-sulfide bodies and pyrite veins containing disseminated gold.

Surficial glacial deposits are present throughout the northern and southern Wrangell Mountains; active glaciation occurs in the higher elevations. Mount Wrangell, a large shield volcano, periodically exhibits steam activity at its summit. Mud volcanoes in the Copper River Basin, near the west flank of Mount Drum, occasionally erupt warm saline mud.

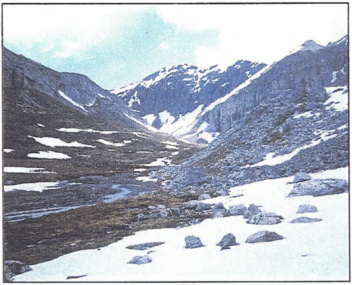


Photo 3. - The Copper King Mine on upper Elliott Creek showing the distinct cliffs of the Chitistone Limestone, looking east. Photo by Mark P. Meyer

EXPLANATION

Volcanic Rocks

QTvi --- Quaternary and/or Tertiary intermediate volcanic rocks.

lTvm --- Lower Tertary mafic volcanic volcanic rocks.

KJvm --- Cretaceous and Jurassic mafic volcanic rocks.

Trvm --- Triassic mafic volcanic rocks.

Intrusive Rocks

Tif --- Tertiary felsic intrusive rocks.

Kif --- Cretaceous felsic intrusive rocks.

Kii --- Cretaceous intermediate intrusive rocks.

Ki --- Cretaceous undifferentiated intrusive rocks.

Jii --- Jurassic intermediate intrusive rocks.

JTrii --- Jurassic and/or Triassic intermediate intrusive rocks.

Pif --- Pennsylvanian intermediate intrusive rocks.

Pim --- Pennsylvanian mafic intusive rocks.

uPzim --- Upper Paleozoic mafic intrusive rocks.

Sii --- Silurian intermediate intrusive rocks.

Pzim --- Paleozoic mafic intrusive rocks.

Pzi --- Paleozoic intermediate intrusive rocks.

Ultramafic Rocks

PPu --- Pennsylvanian ultramafic rocks.

Pzu --- Paleozoic ultramafic rocks.

Stratified Sedimentary Sequence

Qh --- Holocene deposits. Alluvial, glacial, lake, swamp, landslide, and flood plain deposits.

Qp --- Pliestocene deposits. Alluvial, glacial, dune sand, loess, and reworked sand and silt deposits.

uT --- Upper Tertiary rocks. Sandstone siltstone, shale, mudstone, and conglomerate of Miocene and Pliocene age.

mT --- Middle Tertiary rocks. Siltstone, sandstone, organic shale, and locally volcanic rocks.

lT --- Lower Tertiary rocks. Continental clastic rocks of Palecene and Eocene age.

K --- Cretaceous rocks. Shelf deposits of sandstone, siltstone, shale, and limestone of the Kennicott and Chititu Formations.

lK --- Lower Cretaceous rocks. Interlayed submarine and subaerial andesitic fragmental volcanic detritus, and interbedded mafic volcanic rocks.

KJ1 --- Cretaceous and Upper Jurassic rocks. Graywacke, slate, argillite, minor conglomerate, volcanic detritus, and interbedded mafic volcanic rocks.

KJ2 --- Lower Cretaceous and Upper Jurassic rocks. Shallow and deep water clastic deposits (Oxfordian to Barremian) north of the Wrangell Mountains.

J --- Jurassic rocks. Shale, siltstone, and sandstone of the Nizina Mountain Formation and the Kotsina Conglomerate along the southern Wrangell Mountains.

JTr --- Jurassic and/or Triassic rocks. Limestone with minor dolomite, shale, and chert of the Chitistone Limestone, Nizina Limestone, and the McCarthy Formation along the southern Wrangell Mountains.

TrP --- Triassic and Permian rocks. Mafic volcanic rocks, limestone, and calcareous argillite.

PPP --- Permien and Pennsylvanian rocks. Basaltic to andesitic lavas and derivative volcaniclatic rocks, tuffs, minor gabbro, and local shallow-water sedimentary rocks metamorphosed to greenshist facies, and locally, amphilbolite facies. Includes the Skolai Group, Strelna Formation (Permian), and Tetelna Volcanics.

Pz --- Paleozoice rocks. Marble in places containing tremolite.

D --- Paleozoic rocks. Pyroclastic rocks and ash flows interbedded with sedimentary rocks metamorphosed to schist and gniess.

Continental Deposits

Tmc --- Miocene continental deposits. Sandstone, siltstone, shale, claystone, and conglomerate.

TKc --- Tertiary and Cretaceous continental deposits. Conglomerate, breccia, sandstone, arkose, mudstone, shale, and tuffaceous rocks.

Other

Water

Ice

Map symbols

Fault

Fault, dotted where concealed

Park and preserve boundary

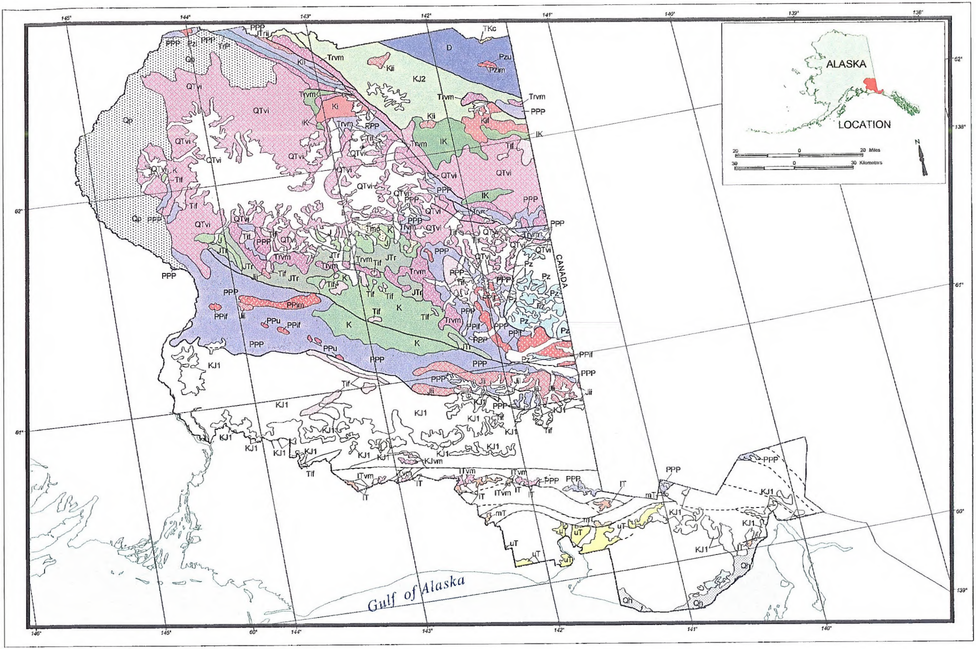


Figure 2. - Geologic map of the Wrangell-St. Elias National Park and Preserve.
(adapted from Geologic Map of Alaska by Helen M. Beikman - 1980)

MINERAL RESOURCES

Mineral resources in the Wrangell Mountains include bismuth, copper, corundum, gold, iron, lead, molybdenum, silver, zinc, reported platinum group metals, and reported uranium. Copper is the most abundant resource in the area. Silver and gold are the next abundant resources occurring alone or as byproducts of copper deposits. Gold is also found in placer deposits. Other minerals explored for in the study area include corundum and molybdenum.

Four types of occurrences occur in the study area and are listed in Table 3. They include copper, gold, corundum, and molybdenum.

COPPER DEPOSITS

Moffit and Mertie (1923), described in detail, the copper deposits in the southern Wrangell Mountains. They identified two types of deposits, stringer lode deposits and contact deposits. Stringer lodes, the more common type, occur in either shear zones along fault planes or in fractures and locally extend into the country rock. Contact deposits consist of disseminated and locally massive bodies of mineralized rock at or near the contact with granodiorite plutons (Moffit and Mertie, 1923).

Stringer Lodes

Five types of stringer lode deposits were identified. They include argentiferous tetrahedrite, chalcocite, bornite and bornite-chalcocite, bornite-chalcopyrite, and pyrite-chalcopyrite deposits (Moffit and Mertie, 1923).

Argentiferous tetrahedrite occurs at only one locality, the Silver Star Mine. Sulfide minerals include tetrahedrite, chalcopyrite, galena, and minor bismuthinite. Copper oxide minerals include azurite and malachite. Silver-bearing tetrahedrite occurs as stringers cutting quartz and barite gangue material (Moffit and Mertie, 1923).

Chalcocite deposits (Kennecott type deposit) are generally missing from the Kotsina-Kuskulana district. These deposits are located to the east making up the Kennecott Corporation and Mother Lode Coalition mines along the Kennicott River and McCarthy Creek drainages. The Kennecott deposit is discussed in more detail at the end of this section. Sulfide minerals include chalcocite and occasional covellite. Gangue minerals include epidote and specular hematite (Moffit and Mertie, 1923). The Skyscraper prospects are the closest to this type of deposit. Chalcocite and native copper have been found at the Snowshoe claim and as float at the Skyscraper prospect (Moffit and Mertie, 1923).

Bornite is the most common copper mineral in Kotsina-Kuskulana district. However, none of the bornite deposits are exclusively bornite as they usually grade into bornite-chalcocite deposits. Chalcocite most commonly occurs as stringers and patches in the bornite, but has been noted as a granular mass of equal amounts of bornite, chalcocite, and quartz. Pyrite and malachite are present in small amounts. Gangue minerals include quartz and calcite (Moffit and Mertie, 1923). Deposits include the Copper King, Hubbard-Elliott, and Nugget Creek mines and the Divide Creek, Falls Creek, Hidden Treasure, Homestake, Newhome, Sunrise, and Sunset prospects.

In the bornite-chalcopyrite deposits, bornite is the primary mineral, chalcopyrite is secondary, and chalcocite is absent. Pyrite is usually not present. Gangue includes quartz, epidote, and jasper (Moffit and Mertie, 1923). Localities include the Mullen Mine and the Bluebird, Cave, Fall Creek

TABLE 3 - Mineral occurrence types and descriptions (Moffit and Mertie, 1923).

Mineral deposit type	Description
	COPPER DEPOSITS
Stringer lodes	
Argentiferous tetrahedrite	Silver-bearing tetrahedrite occurs as stringers cutting quartz and barite. Minerals include tetrahedrite, chalcopyrite, galena, bismuthinite, azurite, and malachite.
Chalcocite (Kennecott type deposits)	Deposits occur as massive to tabular bodies replacing limestone. Minerals include chalcocite and covellite along with minor amounts of chalcopyrite, sphalerite, and galena.
Bornite and bornite-chalcocite	Deposits occur as veins along shear zones and fault planes, and locally deposited in the country rock. Minerals include bornite, chalcocite, pyrite, and malachite in quartz and calcite gangue.
Bornite-chalcopyrite	Deposits occur as veins along shear zones and fault planes, and locally deposited in the country rock. Minerals include bornite, chalcopyrite, and malachite in quartz, epidote, calcite, and jasper gangue.
Pyrite-chalcopyrite	Deposits occur as small ore bodies locally deposited in the country rock. These ores are the lowest grade copper deposits in the study area. Minerals include pyrite, chalcopyrite, gold, and silver.
Contact deposits	
Disseminated to metamorphic	Deposits occur as disseminations in the country rock at or near the borders of large batholiths, plutons, dikes, or sills. Minerals include pyrite, chalcopyrite, garnet, and magnetite in calcite gangue
	GOLD DEPOSITS
Lode	Deposits occur as veins along shear zones and fault planes near contact between igneous intrusives and carbonaceous rocks. Minerals include gold, hematite, pyrite, chalcopyrite, and native tellurium in quartz and calcite gangue.
Placer	Deposits form in a rough spatial association with lode sources of the metals present in a drainage basin. Minerals include native gold.
Nabesna type	Gold-rich copper skarn. Deposits occur along the contact of plutons and limestones. Minerals include pyrite, chalcopyrite, galena, sphalerite, and gold in calcite and quartz gangue.
	OTHER DEPOSITS
Corundum	Deposits occur as crystals in pegmatite syenite dikes that cut a large meta-igneous complex.
Molybdenite	Deposits occur as flakes, blebs, and veinlets in pegmatite syenite dikes which cut a large meta-igneous complex.

Upper, Forget-Me-Not, Lime Creek, Peacock Claim, Roaring Creek, Skyscraper Peak West, Surprise/Sunshine, and the Warner prospects.

Pyrite-chalcopyrite deposits are the lowest grade copper deposits that occur in the study area. They only form small sulfide bodies. Their economic viability is doubtful as copper producers, but they may contain significant quantities of gold and silver (Moffit and Mertie, 1923). Pyrite-chalcopyrite deposits in the southern Wrangell Mountains include the Ammann, Amy Creek, Barrett Young and Nafsted, Franklin, Kinney-Golden, Kotsina River, Larson, and Surprise Creek prospects. Several properties in the northern Wrangell Mountains appear to fit into this deposit type. These include the Antler Creek North, Antler Creek South, Camp Creek, Trail Creek, Trail Creek Cirque, and Trail Creek Shear prospects and one unnamed occurrence.

Contact Deposits

Low grade copper deposits that are distinct from the stringer lodes constitute the contact deposits. They typically occur at or near the borders of large intrusive bodies and consist of disseminated sulfides and occasional bodies of solid minerals. The deposition of contact deposits is most likely through ascending heated meteoric waters in association with intrusive bodies (Moffit and Mertie, 1923). Those intrusive bodies include the Chitina Valley batholith, and Tertiary and Cretaceous plutons, dikes, and sills. Sulfide minerals are exclusively pyrite and chalcopyrite. Gangue minerals include calcite and magnetite (Moffit and Mertie, 1923). Examples of contact deposits in the southern Wrangell Mountains include the Berg Creek and Clear Creek mines and the Calcite, Copper Queen, London and Cape, Porcupine Creek, and War Eagle prospects. Properties in the northern Wrangell Mountains include the Nabesna, Rambler, and Royal Development Co. mines and the Caribou Creek, Corundum, Fennimore and Rasmussen, and Rock Creek Moly prospects.

Gold Deposits

Lode gold has only been found in sufficient quantities to warrant exploration at a few locations in the Wrangell Mountains. Generally it is a byproduct of copper mineralization. Properties where the gold values were higher than the copper values or gold was considered the primary mineral include the Berg Creek, Copper King, Nabesna (discussed in more detail at the end of this section), and Rambler mines.

Placer gold has been found in river gravels in the following drainages within the study area: Caribou Creek, Rock Creek (Vicky), and Trail Creek in the northern study area and the Chokosna River (Escape), Kotsina River, and Lakina River (Carmalita) in the southern study area.

Molybdenite and Corundum Deposits

Molybdenite and corundum have been located in the northern Wrangell Mountains at the Rock Creek Moly and Corundum prospects. Country rock at the Rock Creek Moly prospect consists of syenite and gneiss (Moffit, 1954) cut by a pegmatite dike (Berg and Cobb, 1967). Molybdenite occurs as flakes, blebs, and veinlets in the dike (Moffit, 1941).

At the Corundum prospect, corundum occurs in thin pegmatite dikes that cut the gneiss. The corundum is found as misshapen and fractured gray crystals, associated with muscovite. The source of the corundum may be the late stages of regional metamorphism (Richter, 1970).

KENNECOTT TYPE DEPOSITS

The Kennecott Copper Corporation and Mother Lode Coalition mines (Kennecott) contained the richest copper deposits in the Wrangell Mountains (MacKevett and others, 1997). Over one billion pounds of copper and nine million ounces of silver were produced between 1910 and 1935 from the Jumbo, Bonanza, Erie, and Mother Lode ore bodies. Kennecott is still regarded as one of the highest grade copper deposits in the world.

The deposition of the Kennecott type ores is restricted to the Kennicott River and McCarthy Creek vicinity. The deposits consist primarily of massive chalcocite with minor covellite along with traces of bornite, chalcopyrite, sphalerite, and galena (Bateman and McLaughlin, 1920; Moffit and Mertie, 1923; Bateman, 1950). Chalcocite commonly occurs as relatively pure lenses and masses, while noticeably absent are quartz, pyrite, and other typical gangue minerals (Bateman, 1950). Bedrock units controlling the deposition of ore are the Nikolai Greenstone and the overlying Chitistone Limestone (Birch, 1925). Warm, meteoric waters moving through the greenstone, removed copper and transported it along fissures in the limestone (Jensen and Bateman, 1981; MacKevett and others, 1997) and deposited the minerals with a distinct contact (Bateman, 1950) in the upper dolomite unit of the Chitistone Limestone (Douglass, 1964).

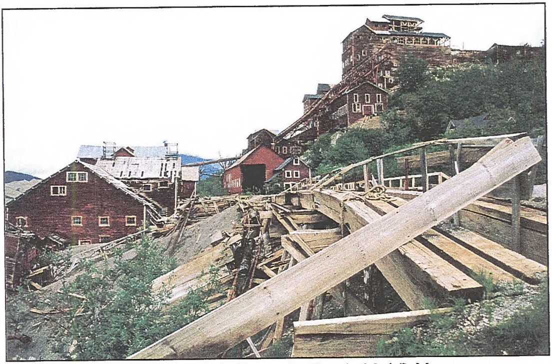


Photo 4. - Kennecott Mill buildings, looking north. Photo by Mark P. Meyer.

NABESNA TYPE DEPOSITS

The Nabesna Mine deposit has been classified as a gold-rich copper skarn. The skarn, along with its sulfide and magnetite ore, form a very complex association (Newberry and others, 1997). The deposit formed by the intrusion of a Cretaceous quartz diorite pluton into massive, nearly horizontal Triassic (Nabesna?) limestone resulting in alteration, especially along the contact (Moffit, 1936). Ore minerals include pyrite, chalcopyrite, galena, sphalerite, and gold. Calcite and garnet are the most common gangue minerals while quartz occurs mainly in the upper part of some veins (Moffit, 1954).

Three types of ore deposits occur within the skarn: 1) veins containing pyrite, chalcopyrite, sphalerite, and galena with calcite and quartz as gangue minerals; 2) bodies of massive magnetite with pyrite and some gold; and 3) veins and masses of pyrrhotite containing disseminated pyrite, chalcopyrite, and gold (Richter, 1997). Other deposits containing mineralization associated with the Nabesna type gold deposits include the Rambler and Royal Development Co. mines also located at White Mountain.

Photo 5. - The Nabesna Mine mill and mine workings, looking northwest at White Mountain. Photo by Mark P. Meyer.

MINERAL DEPOSIT MODELS

Mineral deposit models based on Cox and Singer (1986) were identified in the Wrangell Mountains to assist in conducting an economic analysis for this study. Deposit models include basaltic copper, carbonate hosted gold-silver, copper skarn, iron skarn, granitoid hosted gold, pegmatite, polymetallic vein, and porphyry copper-molybdenum. The basaltic copper, copper skarn, iron skarn, and polymetallic vein models are the only ones discussed in this report as they represent the most likely types to be mined in the study area (Table 4). Economic prefeasibility analysis were competed on basaltic copper, polymetallic vein, and iron skarn deposits by Coldwell (2000) and are discussed in more detail in the economic analysis section.

Basaltic copper forms in the upper parts of copper-rich basalt sequences and overlies limestone and shale deposits (Kennecott type deposits). The ore bodies may form large pipes or lenses replacing limestone along breccia zones and fractures. Copper minerals consist mainly of chalcocite with minor amounts of native copper, bornite, chalcopyrite, malachite, and azurite (Cox and Singer, 1986; Nokleberg and others, 1987).

Copper skarns form mainly where igneous rocks intrude limestone. Irregular or tabular ore bodies form in the limestone near their contacts. Ore minerals include chalcopyrite and pyrite, and possible gold, silver, hematite, magnetite, bornite, and pyrrhotite (Cox and Singer, 1986).

Iron skarn deposits form mainly as the replacement of limestone along its contact with igneous intrusive or volcanic rocks (Nabesna type deposits). The ore mineral is primarily magnetite but can include chalcopyrite, pyrite, and pyrrhotite (Cox and Singer, 1986).

Polymetallic vein deposits consist of quartz-carbonate veins related to igneous intrusions into carbonate and metamorphic rocks. Ore bodies form along intrusive contacts, fault intersections, and breccia pipes. Ore minerals include native gold, silver, electrum, sphalerite, chalcopyrite, galena, arsenopyrite, and tetrahedrite (Cox and Singer, 1986; Nokleberg and others, 1987).

TABLE 4 - Mineral deposit models and descriptions (Cox and Singer, 1986).

Mineral deposit model	Description
Basaltic copper	Deposited in upper parts of basalt sequences and overlying limestone. Ore mineralogy features chalcocite, native copper, bornite, and chalcopyrite.
Copper skarn	Deposited in limestone in close contact with igneous intrusives. Ore mineralogy features chalcopyrite and pyrite, and possible gold, silver, bornite, and pyrrhotite.
Iron skarn	Deposited as replacement of limestone or calcareous rocks along intrusive contact with diorite, granodiorite, granite, or volcanic rocks. Ore mineralogy features magnetite, chalcopyrite, pyrite, and pyrrhotite.
Polymetallic vein	Related to hypabyssal igneous intrusions in sedimetary and metamorphic rocks. Veins consist of small dike swarms and sills. Ore mineralogy features native gold and silver, sphalerite, chalcopyrite, galena, arsenopyrite, and tetrahedrite.

SITE INVESTIGATIONS

Site investigations were completed on 46 identified mineral occurrences (5 in the northern area and 41 in the southern area). A total of 110 samples were collected and analyzed with the results listed in the Final Report - Appendix A (Meyer and others, 2000). Thirty properties were identified to contain highly anomalous mineral values. Eighteen are located within Ahtna, Inc. selections (Table 5) and twelve are located outside the selections (Table 6). This section will only describe those 27 properties sampled by the Bureau. Detailed discussions of all the sample results and property descriptions can be found in the Final Report.

Northern Wrangell Mountains

During the investigation of the northern Wrangell Mountains five adits along with two placer occurrences were located as shown on Figure 3. A total of 31 samples were collected and analyzed from the area (Final Report, Appendix A). The major historically producing operations in the northern area include the Caribou Creek, Nabesna, Royal Development Co., and Rambler mines.

Properties with anomalous mineral values located within Ahtna, Inc. selections are the Caribou Creek and Rambler mines and the Trail Creek placer prospect.

Caribou Creek Mine: (Figure 4, Inset A) The mine was a hydraulic placer operation that utilized a 3-in.-diameter hose and a 12-in.-wide sluicebox ("Long Tom") of unknown length. A wing dam, with wooden gates, was built to control water flow in the creek and create a head for the hydraulic nozzle. The area worked covered approximately 1 to 1½ miles of the creek and is marked by boulder piles on both sides of the creek. The workings are located between a lower cabin, which is still used by hikers, and an old tent site. Stream float consists of basalt, rhyolite, and aplitic dike boulders. One placer sample contained two small angular gold flakes approximately ½ mm in diameter. A second sample contained six small flakes of gold up to ½ mm in diameter. Analytical results of the concentrates contained up to 5,227 ppb gold, 0.6 ppm silver, and 33 ppm copper.

Rambler Mine: (Figure 5, Inset B) The upper and lower adits were located. Improvements include four buildings (assay, office, bunkhouse, and storage shed), an ore bunker, a metal-lined ore

Photo 6. - BLM employee sampling the upper vein at the Rambler Mine. Upper adit shown in lower left corner. Photo by Mark P. Meyer.

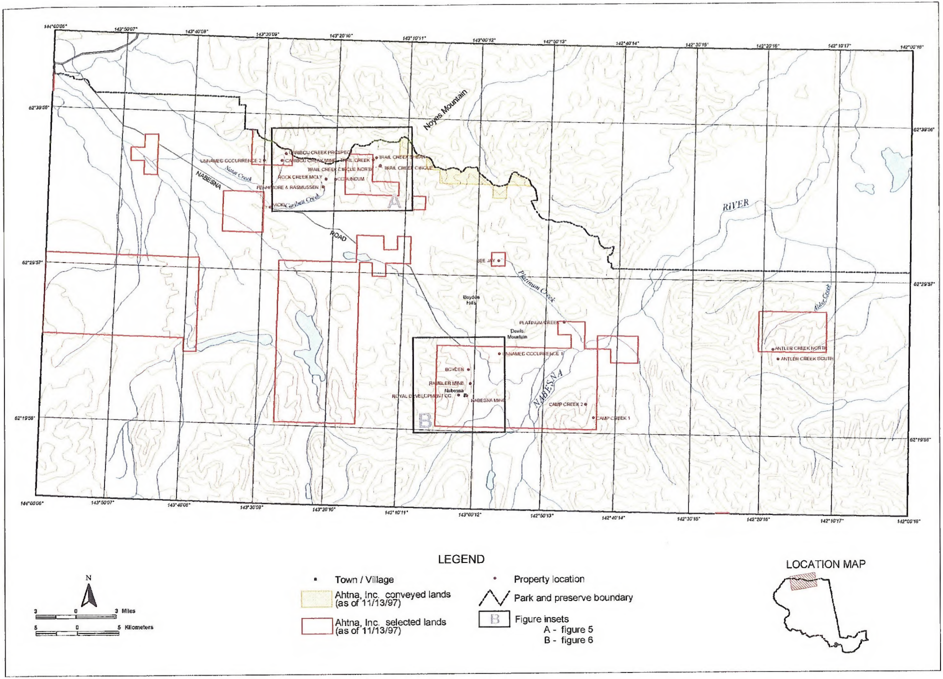


Figure 3. Property location map of the northern study area Wrangell-St. Elias National Park and Preserve.

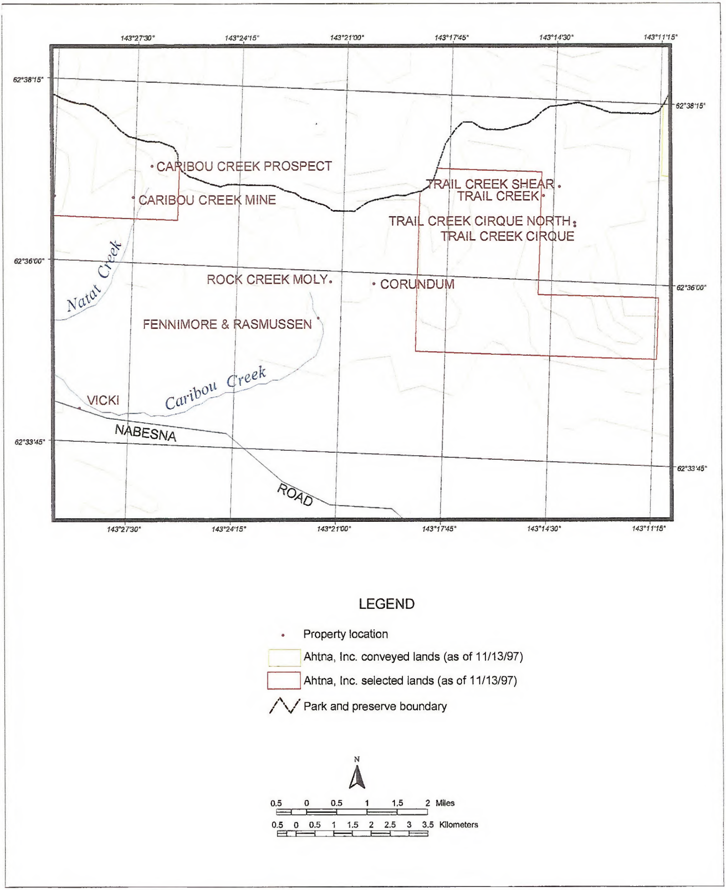


Figure 4. Inset A (Fig. 3), property location map of the northern study area .

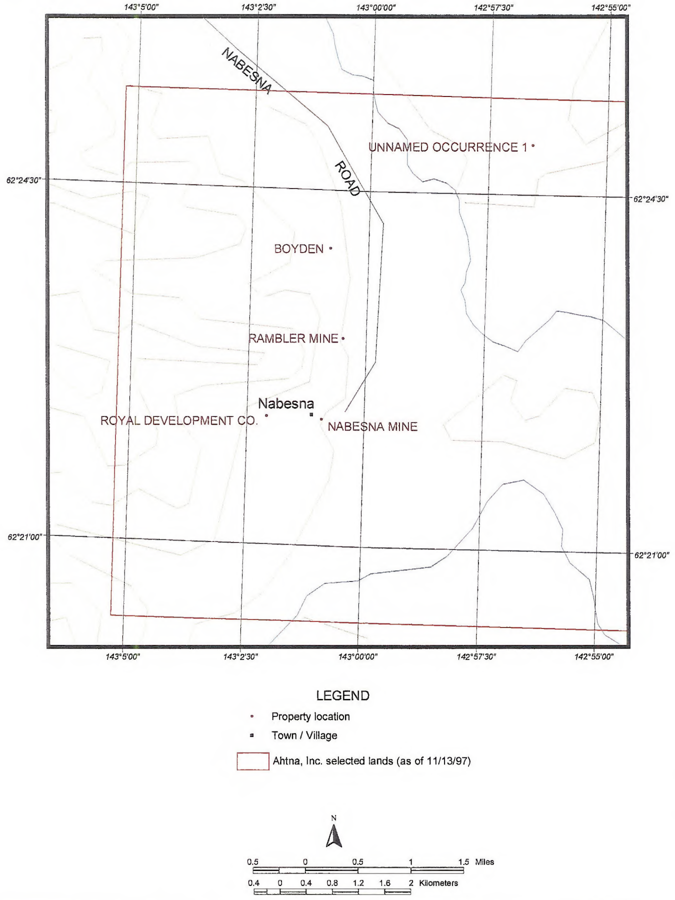


Figure 5. Inset B (Fig. 3), property location map of the northern study area.

TABLE 5 - Highest analytical results of selected properties within Ahtna, Inc. selections in the Wrangell-St. Elias National Park and Preserve.

Name	Cu (%)*	Ag (ppm)	Au (ppb)*	Pb (ppm)	Zn (ppm)	Sample nos.
Northern Wrangell Mountains						
Caribou Creek Mine**	33 ppm	0.4	5,227	21	84	10014-15
Rambler Mine	3,301 ppm	103.3	8.68 ppm	1,960	3,956	10027
Trail Creek**	73 ppm	0.3	4,321	29	108	10029-31
Southern Wrangell Mountains						
Clear Creek Mine	8.8	66.3	9,828	30	1,208	10054-58
Copper King Mine	13.4	17.2	16	11	30	10063
Mullen Mine	36.6	109.7	45	19	45	10039-40
Silver Star Mine	2.6	1,677.1	177	404	3,060	10034-36
Ammann	1.2	6.4	8	4	13	10041
Barrett Young and Nafsted	7,939 ppm	0.7	50	5	106	10082
Carmalita**	55 ppm	<0.2	2,411	<2	113	10095
Fall Creek Upper	1.94	6.4	6	8	72	10087
Hidden Treasure	3.3	3.0	12	<2	73	10052
Homestake	2.9	8.5	8	<2	71	10038, 85
Larson West	6,714 ppm	2.0	6	4	68	10096-97
Lime Creek	24.03	4.8	608	12	58	10071
Newhome	2.61	11.6	20	32	110	10100-01
Sunrise	2.77	8.9	10	9	86	10086
Sunset	9.56	32.4	6	34	206	10098-99

* Unless otherwise noted. ** Placer concentrate samples.

shoot with a cabled ore car between the adits, and a generator. The No. 1 Adit is iced-in. A shear zone above the adit contains massive pyrite, pyrrhotite, and chalcopyrite. The No. 2 Adit is also iced-in. No visible copper mineralization was noted in the No. 2 Adit. Analytical results contained up to 3,301 ppm copper and 103.3 ppm silver.

Trail Creek prospect: (Figure 5, Inset A) A placer prospect on Trail Creek was looked for but not located. There has been reported prospecting in the past, but this may have been confused with the workings on Caribou Creek. Stream float consists of basalt, diabase, greenstone, and limestone. Three placer samples were collected with very minor gold recovery in the samples. Two samples were collected in the main drainage. The

TABLE 6 - Highest analytical results of selected properties outside Ahtna, Inc. selections in the Wrangell-St. Elias National Park and Preserve.

Name	Cu (%)*	Ag (ppm)	Au (ppb)*	Pb (ppm)	Zn (ppm)	Sample nos.
Southern Wrangell Mountains						
Berg Creek Mine	4,514 ppm	316.2	48.48 ppm	12	26	10059-60
Nugget Creek Mine	10.65	61.5	16	117	337	10079
Bluebird	50.2	103.6	32	37	47	10044-45
Cave Prospect	17.0	30.6	533	22	41	10043
Divide Creek	3.43	10.6	98	32	110	10102-04
Falls Creek	6.2	6.2	329	4	29	10064-65
Forget-Me-Not	1.89	3.2	<5	87	60	10105
Mountain Sheep	3	3.1	<5	131	68	10106
Peacock Claim	3.1	4.8	77	2	59	10042
Roaring Creek	23.02	23.4	43	50	334	10089-90
Surprise/Sunshine	20.5	6.6	2,938	11	81	10093-94
Warner	3.46	3.8	16	13	180	10070

* Unless otherwise noted.

first sample contained four to five fine gold specks up to 1 mm. The second sample contained two small gold specks. The third sample taken from Trail Creek recovered two gold specks. Analysis of the concentrates contained up to 4,321 ppb gold, 0.3 ppm silver, and 73 ppm copper.

Southern Wrangell Mountains

Investigations were completed on 41 identified properties in the southern Wrangell Mountains as shown on Figure 6. On those properties, 52 adits and 26 opencuts were located. A total of 79 samples were collected and analyzed from the area (Final Report, Appendix A). The major historically producing operations include the Berg Creek, Clear Creek, Copper King, Hubbard-Elliott, Mullen, Nugget Creek, and Silver Star mines.

Properties with anomalous mineral values located within Ahtna, Inc. selections include the Clear Creek, Copper King, Mullen, and Silver Star mines and the Amman, Barrett Young and Nafsted, Carmalita, Fall Creek Upper, Hidden Treasure, Homestake, Larson, Lime Creek, Newhome, Sunrise, and Sunset prospects (Table 1). Those properties located outside Ahtna, Inc. selections include the Berg Creek and Nugget Creek mines and the Bluebird, Cave, Divide Creek, Falls Creek, Forget-Me-Not, Mountain Sheep, Peacock Claim, Roaring Creek, Surprise/Sunshine, and Warner prospects (Table 2).

Kluvesna River Prospects

The Kluvesna River drainage includes the Fall Creek tributary. Prospects of interest include

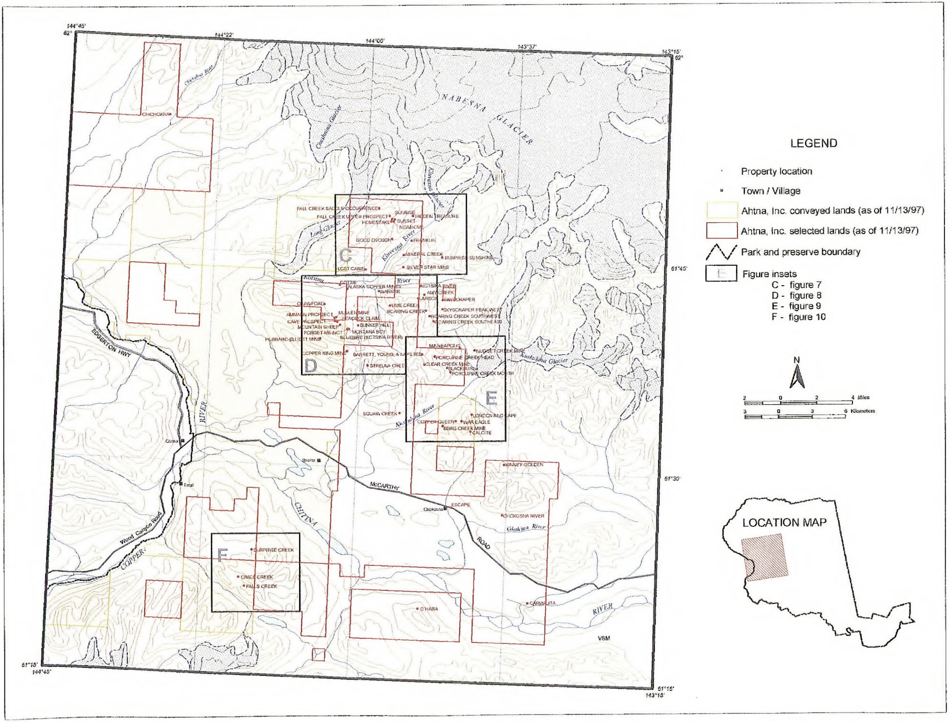


Figure 6. - Property location map of the southern study area Wrangell-St. Elias National Park and Preserve.

the Fall Creek Upper, Hidden Treasure, Homestake, Newhome, Sunrise, and the Sunset prospects as shown on Figure 7.

Fall Creek

Fall Creek Upper prospect: Workings consist of an opencut along a highly iron-oxide stained shear zone within the Nikolai Greenstone. Bornite, chalcopyrite, pyrite, malachite, and azurite occur in epidote and quartz veins within the shear. The mineralized zone covers an area of approximately 30 sq. ft. along the length of the opencut. A sample contained 1.94% copper, 6.4 ppm silver, and 6 ppb gold.

Hidden Treasure prospect: Two opencuts in what appears to be medial moraines near the head of a cirque were located. A reported tunnel was not located. The lower opencut contains malachite-stained vesicular Nikolai Greenstone containing bornite. A sample contained 3.3% copper and 3.0 ppm silver.

Homestake prospect: One adit is driven into vesicular Nikolai Greenstone containing native copper, bornite, chalcopyrite, stephanite, malachite, and azurite. The mineralized area is approximately 50 ft. high by 100 ft. wide. A shear zone to the south of the adit contains native copper. An opencut is located in a gully above the adit. Bedrock in the opencut consists of iron-oxide stained Nikolai Greenstone which hosts quartz veins containing pyrite and chalcopyrite. Samples contained up to 2.9% copper, 8.5 ppm silver, and 8 ppb gold.

Newhome prospect: One adit and three opencuts were located. The adit is driven into Nikolai Greenstone which contains malachite- and azurite-stained quartz and bornite. A shear zone with quartz veins is located outside the portal. Opencut No. 1 is located furthest from the adit to the southwest. The opencut is cut along a shear zone with associated quartz and epidote veining. Bornite, chalcocite, and malachite occur in the shear. Opencut No. 2, located toward the northwest, contains no visible sulfide mineralization. Opencut No. 3 is located directly above the adit. The opencut is cut along a mineralized shear zone with associated quartz veining. Bornite, chalcopyrite, and malachite minerals occur in the shear. Samples contained up to 2.61% copper, 11.6 ppm silver, and 20 ppb gold.

Sunrise prospect: Workings are reportedly located below the Homestake adit. A possible

Photo 7. - BLM geologist inspecting bedrock in the vicinity of the Sunrise prospect. Photo by Darrel A. VandeWeg.

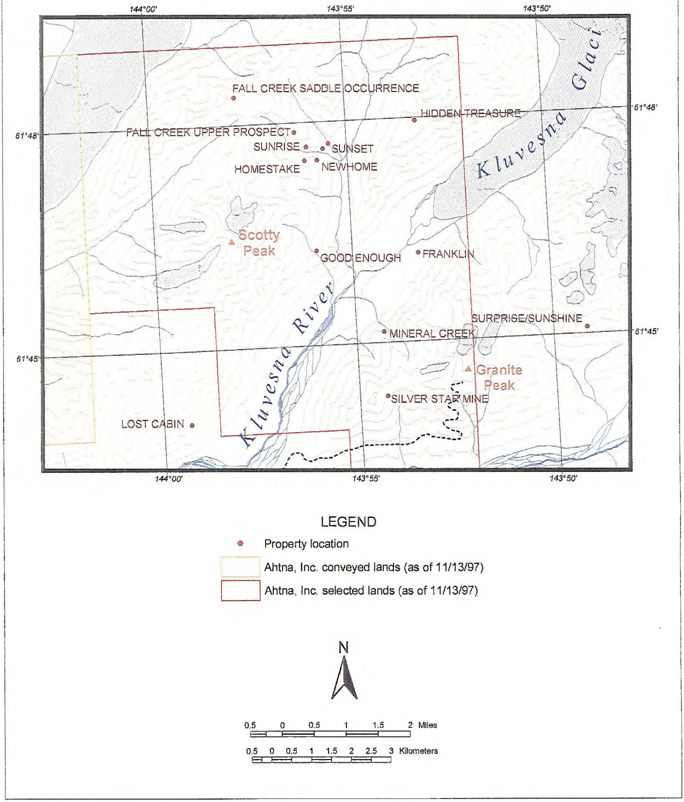


Figure 7. - Inset C (Fig. 4), property location map of the southern study area.

opencut is located at the creek level, but no mineralization was noted. Further down stream, Opencut No. 2 is located on the north side of the stream. Bedrock consists of Nikolai Greenstone hosting quartz veins. Disseminated bornite, chalcocite, and malachite are associated with quartz. Analytical results contained 2.77% copper, 8.9 ppm silver, and 10 ppb gold.

Sunset prospect: Workings consist of a caved adit and an opencut. The adit is driven along a shear zone in the Nikolai Greenstone. The shear contains native copper, bornite, and malachite with associated quartz and calcite veining. The opencut, located upstream from the adit, is dug along a shear zone containing disseminated chalcopyrite, pyrite, and malachite with associated quartz. Analytical results contained up to 9.56% copper, 32.4 ppm silver, and 6 ppb gold.

Kotsina River Prospects

Tributaries of the Kotsina River drainage include Copper, Roaring, and Rock creeks. Properties with anomalous mineral content include the Mullen and Silver Star mines and the Ammann, Bluebird, Cave, Forget-Me-Not, Larson, Lime Creek, Mountain Sheep, Peacock Claim, Roaring Creek, Surprise/Sunshine, and Warner prospects. Their locations are shown on Figure 8.

Copper Creek

Mullen Mine: The Mullen Mine was examined and the underground workings were explored. The map of the Mullen No. 1 Adit published by Van Alstine and Black (1946) is an accurate depiction of the adit. The workings have been mapped and sampled recently by an unknown party, as sample location tags were found at several sample sites. Workings at the Mullen Mine include the Mullen Nos. 1-4 adits and an opencut. The Mullen No. 1 adit is driven along a shear zone in the Chitistone Limestone and contains bornite, chalcopyrite, and quartz. An inclined shaft is located north of the adit at the portal. Two collapsed buildings are located in front of the portal. No visible mineralization was noted at the Nos. 2, 3, or 4 adits. An opencut above the No. 2 Adit, cut into the malachite- and azurite-stained Chitistone Limestone, contains massive chalcopyrite. Samples contained up to 36.6% copper and 109.7 ppm silver.

Photo 8. - Mullen Mine No. 1 adit tailings, looking northwest. Photo by Mark P. Meyer.

Ammann prospect: There are two adits located on this prospect. The upper adit is open and is driven into Chitistone Limestone following calcite veins. No visible mineralization was noted in the adit, veins, or surrounding area. The lower caved adit appears to be driven into Chitistone Limestone with calcite veins containing

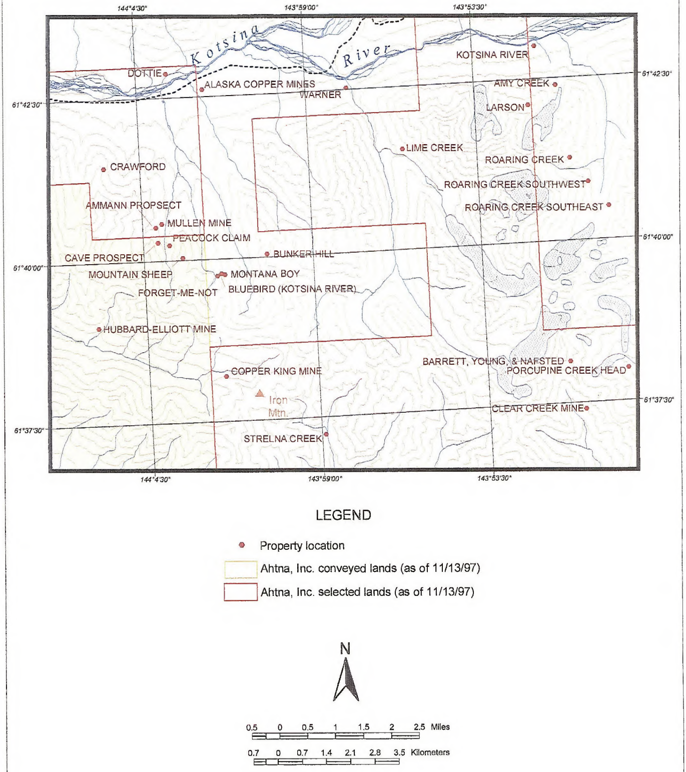


Figure 8. - Inset D (Fig. 4), property location map of the southern study area.

chalcopyrite, pyrite, malachite, and azurite. A sample contained 1.2% copper, 6.4 ppm silver, and 8 ppb gold.

Bluebird prospect: Workings consist of an opencut or caved adit along a highly sheared malachite- and azurite-stained zone in the Nikolai Greenstone containing bornite and chalcopyrite. A shear zone cropping out below the workings contains chalcopyrite. Samples contained up to 50.15% copper and 103.6 ppm silver. The shear zone is a continuation of the shear located at the Forget-Me-Not and Montana Boy prospects.

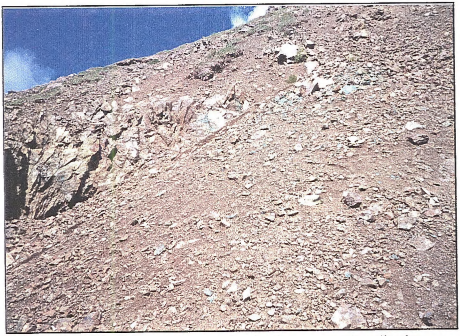


Photo 9. - Bluebird prospect opencut showing the copper mineralization. Photo by Mark P. Meyer.

Cave prospect: Three adits and one opencut are located at this prospect. Adit No. 1 is driven into the Nikolai Greenstone. The workings cut a malachite- and azurite-stained quartz vein containing chalcopyrite. Adit No. 2 is driven along a shear zone in the limestone. The shear zone is malachite- and azurite-stained with small quartz veins. Adit No. 3 is located to the south, driven into a sheared limestone cliff. A small opencut is dug into the limestone above Adit No. 2. but no sulfide mineralization was noted. Analytical results contained up to 17.0% copper, 30.6 ppm silver, and 533 ppb gold.

Forget-Me-Not prospect: Workings consist of a small opencut in sheared and iron-oxide stained Nikolai Greenstone. The shear zone trends to the east across the slope. Chalcocite, bornite, chalcopyrite, pyrite, and malachite occur in the quartz and calcite veined shear zone. A sample contained 1.89% copper and 3.2 ppm silver. This shear zone appears to be a continuation of the mineralized shear zone that occurs at the Bluebird and Montana Boy prospects.

Mountain Sheep prospect: Workings include one adit driven into the Nikolai Greenstone that follows a shear zone. Bornite, chalcopyrite, malachite, and azurite occur in the shear zone. A sample contained 3.0% copper and 3.1 ppm silver.

Peacock Claim prospect: The prospect includes one adit driven into Nikolai Greenstone. Rock mucked from the adit was used to build retaining walls outside the portal. No mineralization was noted in the adit or the waste dump. Chips of chalcopyrite and bornite were included in the retaining wall. A sample contained 3.1% copper, 4.8 ppm silver, and 77 ppb gold.

Roaring Creek

Roaring Creek prospect: Workings consist of a caved adit and an upper opencut. The Camp 3 Tunnel, Adit No. 1 was driven into highly iron-oxide stained and fractured Nikolai Greenstone. Native copper, chalcocite, bornite, malachite, and azurite occur with quartz and calcite veins. The upper opencut is cut into the same bedrock and mineralization as the adit. Samples contained up to 23.02% copper, 23.4 ppm silver, and 43 ppb gold.

Rock Creek

Lime Creek prospect: The prospect consists of an adit driven into sheared Nikolai Greenstone. The adit cuts a shear zone containing rose quartz and calcite. Massive bornite, chalcocite, chalcopyrite, malachite, and azurite occur in the shear. A sample contained 24.03% copper, 4.8 ppm silver, and 608 ppb gold.

Warner prospect: The prospect contains an adit driven into iron-oxide stained Nikolai Greenstone. The adit is driven along a shear zone containing disseminated bornite with quartz and calcite veins. A sample contained 3.46% copper, 3.8 ppm silver, and 16 ppb gold.

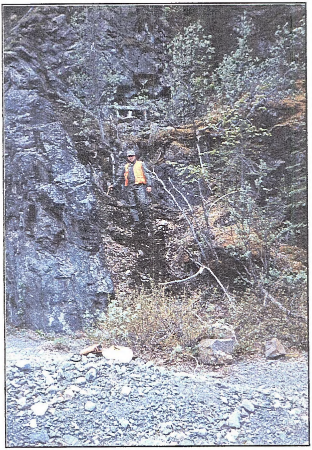


Photo 10. - BLM geologist exiting the Warner prospect adit. Photo by Mark P. Meyer.

Kotsina River

Larson prospect: The East and West adits are located on the south side of the Kotsina River. The Larson East adit is driven into iron-oxide stained Nikolai Greenstone containing disseminated pyrite. The Larson West workings consist of an adit and an opencut. The adit, partially sloughed at the portal, is driven into the greenstone with epidote veins. No visible sulfide mineralization was noted in the adit or in the waste dump. The adit was most likely driven to intercept the mineralized shears trending north-south above the adit. A quartz vein above the adit trending north-south contains chalcopyrite, pyrite, and malachite. An opencut, located north of the adit, was cut along an iron-oxide stained shear containing chalcopyrite, pyrite, malachite, and quartz. Samples from the Larson west vein contained up to 6,714 ppm copper, 2 ppm silver, and 6 ppb gold.

Surprise/Sunshine prospect: Workings consist of one adit and two opencuts. The adit is driven into Nikolai Greenstone. Numerous quartz veins and a shear were noted in the adit. No sulfide mineralization was noted in the adit or the waste dump. Above the adit are two opencuts. Opencut No. 1 is located directly above the adit and Opencut No. 2 is located to the west. Opencut No. 1 was cut across a quartz

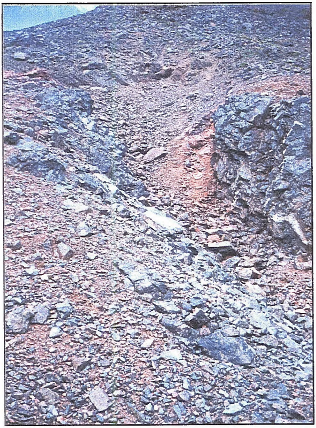


Photo 11. - The Surprise/Sunshine Opencut No. 1 showing the reddish tinted quartz vein. Photo by Mark P. Meyer.

vein. The vein has a dark reddish tint and is malachite- and azurite-stained. Bornite, chalcocite, chalcopyrite, malachite, and azurite occur as pods and are also disseminated throughout the quartz. Opencut No. 2 cuts a white quartz vein. This quartz vein contains more iron-oxide staining than the red quartz vein. Bornite, chalcocite, malachite, and azurite occur in the quartz. Samples contained up to 20.5% copper, 6.6 ppm silver, and 2,938 ppb gold.

Silver Star Mine: This was the last operating mine in the study area, closing in the late 1980's. The property contains two adits, numerous opencuts, and surface stripping. The upper adit is driven through sheared, iron-stained Nikolai Greenstone. Minerals consist of bornite, chalcopyrite, chalcocite, arsenopyrite, malachite, and azurite. The lower adit is caved at the portal. Minerals consist of bornite and chalcopyrite in a quartz and calcite matrix. A stockpile next to an opencut west of the adit contains rock with quartz and calcite veinlets containing blebs of bornite, chalcopyrite, arsenopyrite, and galena. Samples contained up to 2.6% copper, 1,677.1 ppm silver, 3,060 ppm zinc, 404 ppm lead, and 177 ppb gold.

Kuskulana River Prospects

Tributaries within the Kuskulana River drainage include the Berg, Clear, Nugget, and Porcupine creeks. Properties with anomalous mineral content include the Berg Creek, Clear Creek, and Nugget Creek mines and the Barrett Young and Nafsted prospect as shown on Figure 9.

Berg Creek Mine: Ole Berg operated the mine which includes five adits. Tunnel No. 5, the "Working Level," is caved and located at the upper terminus of an aerial tramway. Host rocks in the

Photo 12. - View looking north at the Silver Star Mine. Adits located to the upper left. Photo by Darrel A. VandeWeg.

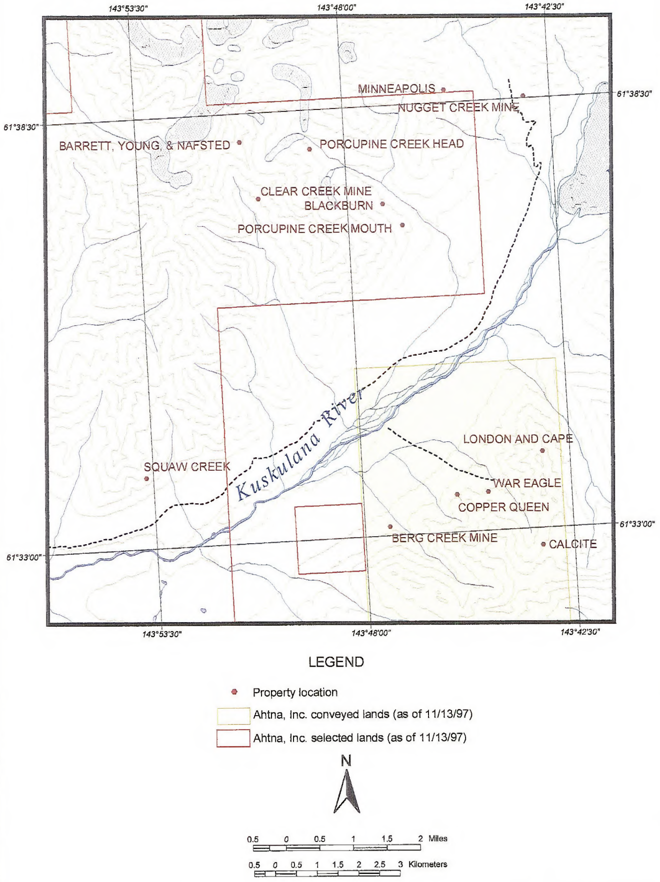


Figure 9. - Inset E (Fig. 4), property location map of the southern study area.

area consist of Nikolai Greenstone and Chitistone Limestone. Minerals include chalcopyrite, malachite, azurite, and pyrite in quartz. Samples contained up to 4,515 ppm copper, 316.2 ppm silver, and 48.48 ppm gold.

Clear Creek Mine: Workings includes four adits and two opencuts. Tunnel No. 1 is driven into Nikolai Greenstone and contains two crosscuts. Minerals of economic interest occur in sheared, iron-stained quartz veinlets and consist of chalcopyrite, bornite, and pyrite. An opencut above the portal exposes a shear zone within the greenstone with disseminated and veins of chalcopyrite. Tunnel No. 2 is caved, but appears to have been driven into a shear zone in the Nikolai Greenstone. Minerals consist of massive and disseminated chalcopyrite, malachite, and azurite. Tunnel No. 3 is iced in. The adit appears to have been driven as a haulage tunnel. No visible mineralization was noted in the waste dump. An opencut located down stream from Tunnel No. 3 is cut to expose an iron-oxide stained vein containing disseminated pyrite and chalcopyrite. Tunnel No. 4 was located further downstream. The adit is caved. No visible mineralization was noted in the waste dump. Samples contained up to 8.8% copper, 66.3 ppm silver, 9,828 ppb gold, 1,208 ppm zinc, 1,329 ppm manganese, and over 10% iron.

Photo 13. - Clear Creek Mine Tunnel No. 1, looking southeast. Photo by Mark P. Meyer.

Nugget Creek Mine: An Upper Adit is driven following an iron-oxide stained shear zone in Nikolai Greenstone. Bornite, malachite, and azurite occur in the shear. A sample contained 10.65% copper, 61.5 ppm silver, and 16 ppb gold.

Barrett Young and Nafsted prospect: None of the reported adits were located. A highly iron-oxide and malachite stained shear zone was located in the drainage. Chalcopyrite, pyrite, malachite, and azurite occur with quartz and epidote. A sample contained 7,939 ppm copper, 0.7 ppm silver, and 50 ppb gold.

Elliott Creek Prospects

The Hubbard-Elliott Copper Co. had extensive workings along Elliott Creek including the Copper King Mine.

Copper King Mine: Workings consist of an ice and snow-covered adit located near the upper camp of the Mineral King Lode claim. The adit was driven into Nikolai Greenstone. Massive chalcocite, bornite, chalcopyrite, malachite, and azurite are associated with quartz. A sample contained 13.4% copper, 17.2 ppm silver, 16 ppb gold, and 1,105 ppm manganese.

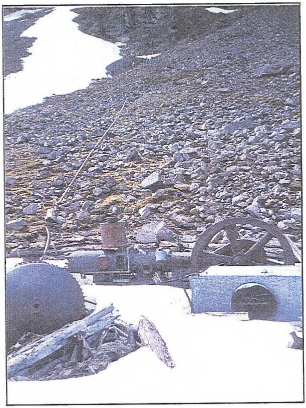


Photo 14. - The Copper King Mine - Mineral King Lode adit. View looking south. Photo by Mark P. Meyer.

Canyon Creek Prospects

The Canyon Creek drainage includes the workings of the Divide Creek and Falls Creek prospects as shown on Figure 10.

Divide Creek prospect: The prospect has four opencuts. Bedrock consists of Skolai Greenstone cut by iron-oxide stained shear zones containing quartz and epidote veining. Opencut No. 1 contains chalcopyrite, malachite, and azurite in quartz veins. Opencut No. 2 contains disseminations and veinlets of pyrite and disseminated bornite in quartz and greenstone. Opencut No. 3 is T-shaped and contains chalcopyrite, pyrite, malachite, and azurite in a shear zone as well as disseminated within the bedrock. Opencut No. 4 is the smallest opencut, and no visible sulfide mineralization was noted. Samples contained up to 3.43% copper, 10.6 ppm silver, and 98 ppb gold.

Photo 15. - Divide Creek Opencut No. 3 copper mineralization. Photo by Darrel A. VandeWeg.

Falls Creek prospect: Workings on this prospect include three adits. Adit No. 1 is driven into highly sheared and fractured Skolai Greenstone with quartz and epidote veins. A shear zone at the portal extends to the north. Chalcopyrite, bornite, malachite, and azurite occur in the shear. Adit No. 2 is located southwest of Adit No. 1. The adit is driven along a shear in the highly sheared and fractured Skolai Greenstone with quartz and epidote veins. No visible sulfide mineralization was noted in the adit, the waste dump, or the surrounding country rock. Adit No. 3 is located across the creek and driven into

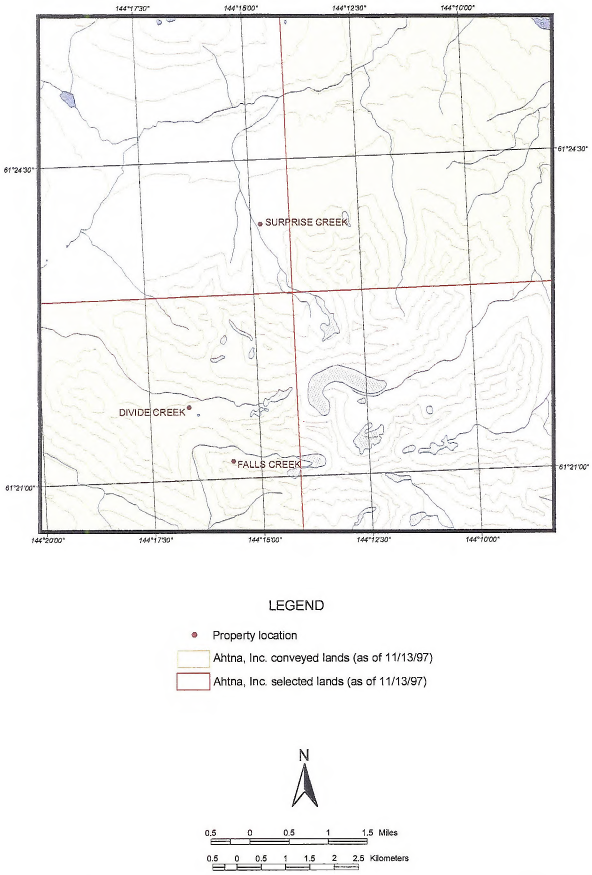


Figure 10. - Inset F (Fig. 4), property location map of the southern study area.

limestone and greenschist. No visible mineralization was noted in the adit or waste dump. Mineralized boulders, scattered along the valley floor, were derived from a shear zone north of Adit No. 1. Disseminated pyrite, chalcopyrite, malachite, and azurite occur with quartz in the boulders. Analytical results contained up to 6.2% copper, 6.2 ppm silver, and 329 ppb gold.

Other Prospects

The Carmalita placer prospect, which contains high gold values, is located on the Lakina River.

Carmalita prospect: (Figure 4) A placer sample was collected on the lower reaches of the Lakina River. Stream float consists of basalt, diorite, granite, and quartz cobbles. The sample contained two very fine specks of gold along with a minor amount of black sands. Analytical results of the concentrates contained 2,411 ppb gold and 55 ppm copper.

Photo 16. The photo shows the Peninsula with Rock Creek draining into the Kotsina River. The Kluvesna River is shown in the foreground. View looking southeast. Photo by Mark P. Meyer.

ECONOMIC ANALYSIS

By James Coldwell, Mining Engineer, BLM, Juneau Mineral Information Center, Juneau, Alaska.

Mining prefeasibility investigations were conducted for basaltic copper, polymetallic vein, and iron skarn deposit models under the terms of a MOU between the BLM, the National Park Service, and Ahtna, Inc. for the mineral assessment of ANCSA Regional Native Corporation selections within the Wrangell -St. Elias National Park and Preserve, Alaska. (Coldwell, 2000).

Mine models were developed for application to the Cox and Singer (1986) mineral deposit models discussed earlier in this publication. Capital and operating costs for the models were determined using the U.S. Bureau of Mines' Cost Estimation System (CES) version 2.3.

As the BLM's mineral assessment did not identify any significant resources on the subject land selections, these economic models are based on hypothetical mining development scenarios of mineral deposits not currently known to exist on Ahtna Inc. ANCSA selections.

These models were developed as a tool to aid in the possible identification of exploration targets on the subject land selections when used as a supplement to this report. Companies often use prefeasibility studies to evaluate their projects to determine if exploration should continue on a project and if it should advance into the development stage.

Published cost information was drawn from industry publications, permitting documents, and environmental impact statements. All costs were escalated by factors that reflect the higher cost of labor, transportation, and electricity in Alaska.

The cost data for each mine model were used to perform a cash flow analysis. The goal of the prefeasibility study was to determine the recoverable metal value (RMV) per short ton of minable ore that would provide a 15% Discounted Cash-Flow Rate-Of-Return (DCFROR) for each of the mine models.

Economic modeling for basaltic copper deposit types indicates the RMV necessary for a 15% DCFROR for an underground mine ranges from $152/st for a 10,209 stpd operation to $224/st for a 1,276 stpd operation.

Economic modeling for polymetallic vein deposit types indicates the RMV necessary for a 15% DCFROR for an underground mine ranges from $155/st at 2,189 stpd to $394/st at 273 stpd.

Economic modeling for iron skarn deposit types indicates the RMV necessary for a 15% DCFROR for an underground mine ranges from $163/st at 6,191 stpd to $259/st at 774 stpd.

The mining prefeasibility study did not provide an in-depth analysis of environmental and socioeconomic concerns. Environmental considerations of mineral development in an area adjacent to a National Park may far outweigh economic considerations.

SUMMARY

Northern Wrangell Mountains

The northern Wrangell Mountains have very few properties with known high mineral values located within or in close proximity to Ahtna, Inc. selected lands. Twenty-two prospects were identified during this study. Fourteen are located within Ahtna, Inc. selections as listed in Table 1 and eight are located outside the Ahtna, Inc., selections as listed in Table 2.

Three prospects favorable for exploration within the selections are the Rambler Mine, the Caribou Creek placer mine, and the Trail Creek placer occurrence as listed in Table 5. These properties along with mineral terranes are shown on Figure 11.

Four properties have been historical producers: Caribou Creek, Nabesna, Royal Development Co., and Rambler mines. The Nabesna and Royal Development Co. mines are patented and a validity determination of the Rambler Mine has been proposed by the NPS.

It is recommended that the Caribou Creek Mine, Rambler Mine, and Trail Creek occurrence should be examined in more detail.

Southern Wrangell Mountains

The southern Wrangell Mountains have numerous properties known to contain high mineral values located within or in close proximity to Ahtna, Inc. selected lands. Sixty prospects were identified during this study. Thirty-two are located within Ahtna, Inc. selections as listed in Table 1 and twenty-eight are located outside the selections as listed in Table 2. Results from the samples collected during the field work identified 26 properties containing high values of copper, as well as anomalous values of silver and/or gold. Fourteen of those are located inside the selections as listed in Table 5 and those located outside the selections are listed in Table 6. Native copper was found at the Homestake, Roaring Creek, and Sunset prospects, whereas bornite, chalcocite, chalcopyrite, malachite, azurite, and/or pyrite were found in various concentrations at all of these properties.

Seven properties located in the southern study area have been historical producers. These are the Berg Creek, Clear Creek, Copper King, Hubbard-Elliott, Mullen, Nugget Creek, and Silver Star mines. Eight properties have been patented including the Clear Creek Mine, the Copper King Mine, the Franklin prospect, the Hubbard-Elliott Mine, the Minneapolis prospect, the Mullen Mine, the War Eagle prospect, and the Warner prospect.

More detailed investigations should be conducted to further delineate the extent of mineralization on those properties favorable for exploration located within Ahtna, Inc. selections as listed in Table 5 and shown on Figure 12. Those properties have shown high mineral values of up to 36.6% copper, silver values up to 1,677.1 ppm, gold values up to 9,828 ppb, zinc values up to 3,956 ppm, and lead values up to 1,960 ppm. These properties include the Clear Creek, Copper King, Mullen, and Silver Star mines and the Ammann, Barrett Young and Nafsted, Fall Creek Upper, Hidden Treasure, Homestake, Larson, Lime Creek, Newhome, Sunrise, and the Sunset

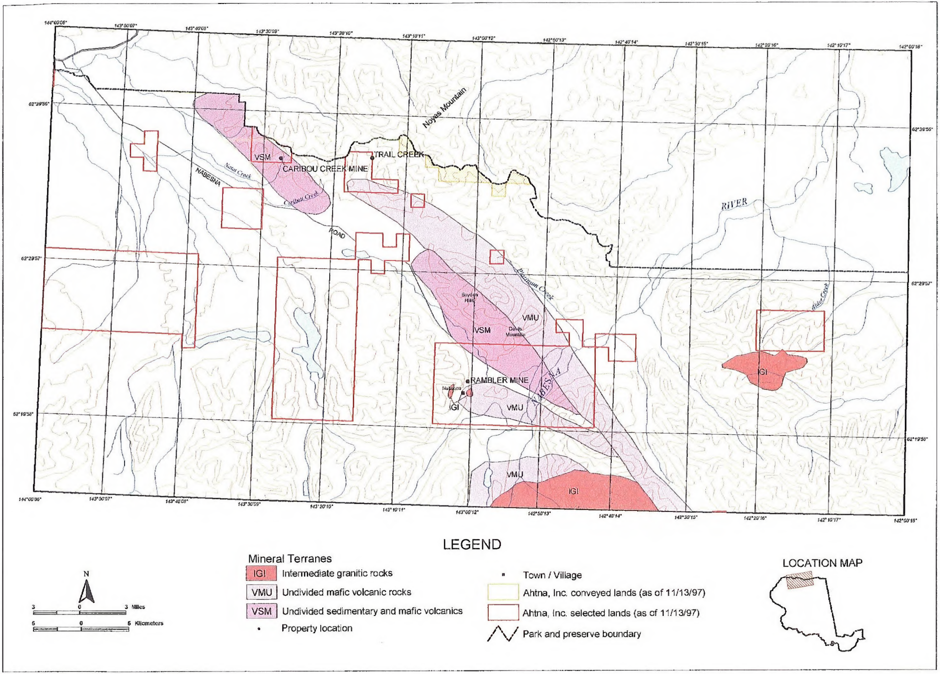


Figure 11. - Mineral Terranes map showing properties favorable for exploration in the northern study area.

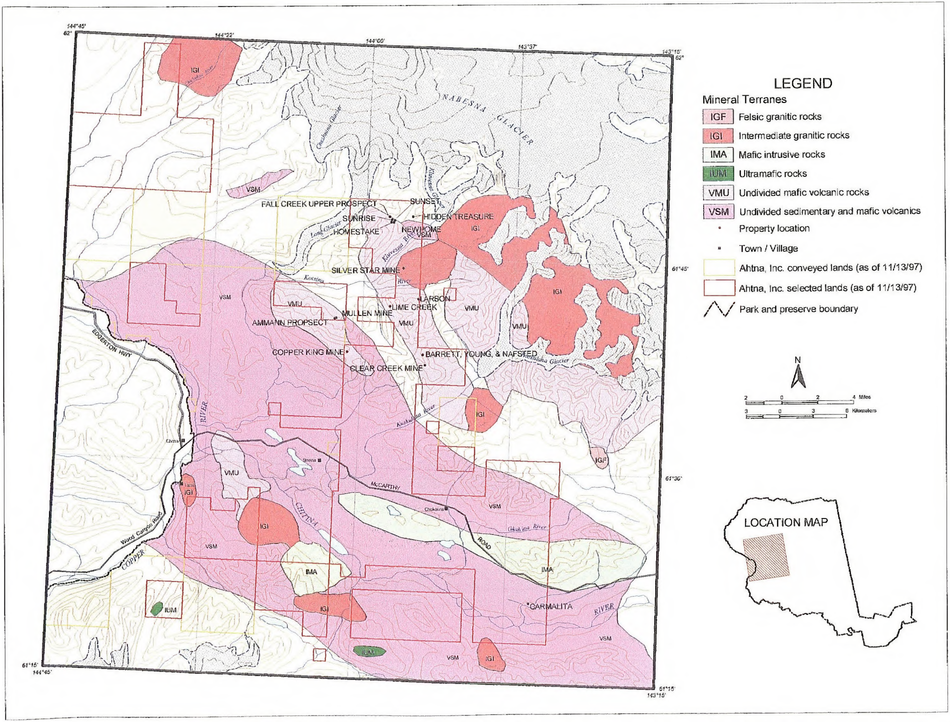


Figure 12. - Mineral Terranes map showing properties favorable for exploration in the southern study area.

prospects. More detailed information is needed on the O'Hara prospect to identify it's mineral potential.

The next stage of exploration techniques need to be incorporated into the investigation of the properties, both in the northern and southern Wrangell Mountains, identified as favorable for exploration to further delineate the extent and grade of mineralization. Exploration techniques that are beyond the scope of this study include airborne magnetic and electromagnetic surveys, induced polarization and magnetic ground geophysical surveys, ground penetrating radar surveys, detailed surface geologic mapping, soil grid sampling, trenching, and exploratory drilling.

It is recommended that Ahtna, Inc. consider any or all of the properties listed in Table 5 during their selection process. Ahtna, Inc. should also consider the availability of the following patented properties: the Copper King and Hubbard-Elliott mines on Elliott Creek, the Mullen Mine on Copper Creek, the Nugget Creek Mine on Nugget Creek, and the Warner prospect on Rock Creek.

Photo 17. - Looking northeast into the headwaters of the Kluvesna River, a tributary of the Kotsina River. Photo by Darrel A. VandeWeg.

REFERENCES

Bateman, A.M., 1950, Economic mineral deposits (2nd Edition): New York, NY, John Wiley and Sons, p. 142-143, 154, 158, 308-309, 502.

Bateman, A.M., and McLaughlin, D.H., 1920, Geology of the ore deposits of Kennecott, Alaska: Economic Geology, v. 15, no. 1, p. 1-80.

Beikman, H.M., 1980, Geologic map of Alaska: U.S. Geologic Survey, 2 sheets, scale 1:2,500,000.

Berg, H.C., and Cobb, E.H., 1967, Metalliferous lode deposits of Alaska: U.S. Geological Survey Bulletin 1246, 254 p.

Birch, S., 1925, Geology and mining methods of Kennecott mines, *in* Transactions of the American Institute of Mining and Metallurgical Engineering, Inc., 1922-1925, Vol. 72, New York, NY, The Institute, p. 499-511.

Coldwell, J.R., 2000, Economic prefeasibility of mining in the Wrangell-St. Elias National Park and Preserve, Alaska: U.S. Bureau of Land Management Open-File Report 77, 20 p.

Cox, D.P., and Singer, D.A., eds., 1986, Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p.

Douglass, W.C., 1964, A history of the Kennecott mines, Kennecott, Alaska, 12 p.

Jensen, M.L., and Bateman, A.M., 1981, Economic mineral deposits (3rd Edition): New York, NY, John Wiley and sons, p. 330.

MacKevett, E.M., Jr., Cox, D.P., Potter II, R.W., and Silberman, M.L., 1997, Kennecott-type deposits in the Wrangell Mountains, Alaska: High-grade copper ores near a basaltic-limestone contact: Economic Geology, Monograph 9, p. 66-89.

Meyer, M.P., VandeWeg, D.A., and Shepherd, A.D., 2000, Mineral assessment of Ahtna, Inc. selections in the Wrangell-St.Elias National Park and Preserve, Alaska. Final Report: U.S. Bureau of Land Management Technical Report 34, 299 p.

Moffit, F.H., 1941, Geology of the upper Tetling River district, Alaska: U.S. Geological Survey Bulletin 917-B, p. 115-157.

-----1936, Upper Copper and Tanana Rivers, Alaska: U.S. Geological Survey Bulletin 868-C, p. 135-143.

-----1954, Geology of the eastern part of the Alaska range and adjacent area: U.S. Geological Survey Bulletin 989-D, 218 p.

Moffit, F.H., and Mertie, J.B., Jr., 1923, The Kotsina-Kuskulana district, Alaska: U.S. Geological Survey Bulletin 745, 149 p.

Newberry, R.J., Allegro, G.L., Cutler, S.E., Hagen-Levelle, J.H., Adams, D.D., Nicholson, L.C., Weglarz, T.B., Bakke, A.A., Clautice, K.H., Coulter, G.A., Ford, M.J., Myers, G.L., and Szumigala, D.J., 1997, Skarn deposits of Alaska, *in* Goldfarb, R.J., and Miller, L.D., eds., Mineral deposits of Alaska: Economic Geology Monograph 9, p. 355-395.

Nokleberg, W.J., Bundtzen, T.K., Berg, H.C., Brew, D.A., Grybeck, D., Robinson, M.S., Smith, T.E., and Yeend, W., 1987, Significant metalliferous lode deposits and placer districts of Alaska: U.S. Geological Survey Bulletin 1786, 104 p., 2 plates.

Richter, D.H., 1970, A corundum occurrence in the eastern Alaska Range, Alaska, *in* Geological Survey research 1970, Chapter C: U.S. Geological Survey Professional Paper 700-C, p. C98-C102.

-----1997, Alaska resource data file - Nabesna quadrangle: U.S. Geological Survey Open-File Report 97-749, 93 p.

Van Alstine, R.E., and Black, R.F., 1946, Copper deposits of the Kotsina-Kuskulana district, Alaska: U.S. Geological Survey Bulletin 947-G, p. 121-141.